Thinking outside the sphere

PROJECT TEST PLAN

IN SUPPORT OF THE

WIRELESS VERIFICATION FOR THE STATE OF UTAH RFP

June 20, 2011

[Ed note: this Test Plan was annotated September 1, 2011 to report minor changes made to the Test Plan. Annotations use this editorial format.]

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SCOPE

Isotrope, LLC is contracted to the International Research Center, LLC to conduct a statewide "drive test" survey of the availability of mobile wireless broadband services in Utah. The project is in support of the State of Utah Public Service Commission's efforts, with the aid of federal State Broadband Data and Development Grant Program.

DEFINING THE REQUIREMENTS

"BROADBAND"

The provision of broadband service in the USA is a national priority. At the spring 2011 CTIA (The Wireless Association) conference March 22, 2011, FCC Chairman Julius Genachowski spoke at length of the role of broadband in our society. Among his remarks, he said,

> *A … report by McKinsey concluded that better utilization of broadband is essential to boosting productivity and growing our economy. That's why the FCC developed the country's first National Broadband Plan a year ago – to identify the key strategic issues our country faces, and set a path forward. One strategic challenge is extending the benefits to the nearly 100 million Americans who currently aren't connected. (www.fcc.gov)*

WORKING SPECIFICATION

In 2009, the Broadband Technology Opportunities Program ("BTOP") began the push for universal broadband availability. The NTIA Notice of Funds Availability describes "broadband" this way,

> *Broadband means providing two-way data transmission with advertised speeds of at least 768 kilobits per second (kbps) downstream and at least 200 kbps upstream to end users, or providing sufficient capacity in a Middle Mile project to support the provision of broadband service to end users.*[1]

Clearly, because the NTIA under the auspices of the SBDD is the administrator of the Project funding, this is the official threshold for benchmarking performance in Utah – services that

[1] NTIA NOFA, Federal Register, Vol. 74, p. 33104, July 9, 2009

have the potential of offering 768 kbps downlink/200 kbps uplink throughput or better ("≥768/200 Service").[2]

By using ≥768/200 Service as a guideline for the development of a Test Plan for the Project, those services that are not capable of delivering true broadband performance can be eliminated from consideration. This is particularly important in a cost-benefit assessment, in which millions of data points, each represented by hundreds of bytes of data, are collected over thousands of miles of roadway. The two primary burdens caused by over-collecting data are 1) committing resources in the test platform design, programming and operation to the measurement of services that are incapable by design of providing the minimum throughput, and 2) committing resources to post processing and presenting the data of such services.

FOCUS ON BROADBAND-CAPABLE WIRELESS TECHNOLOGIES

As further described below in Services to Measure, incumbent wireless networks consist of layers of several generations of technology, which may require certain hardware and software decisions to be made to ensure that the focus of the test and measurement program remains on the objective – broadband performance measurement.

The Test Plan focuses focus on those wireless technologies that are capable of delivering least ≥768/200 Service, even if they might fall short in actual performance at some locations. **These technologies include**[3] 3G and 4G services, as well as networks that have followed lower cost network upgrades only to the most current of the 2G versions[4], which can be capable of crossing the 768/200 kbps threshold under appropriate circumstances. To the extent a provider's service and the data collection system both automatically shift down to slower technologies when fully broadband speeds are unavailable, key data will continue to be collected.

The test apparatus will **log the actual Link Technology**[5] being employed between the user equipment ("UE") and the base facility with each measurement. This is particularly helpful in two ways. First, information on the specific Link Technologies available by location by provider

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[2] It may be interesting to note that the FCC recently raised the bar on its definition of broadband. *The National Broadband Plan recommends as a national broadband availability target that every household in America have access to affordable broadband service offering actual download (i.e., to the customer) speeds of at least 4 Mbps and actual upload (i.e., from the customer) speeds of at least 1 Mbps…. this speed threshold provides an appropriate benchmark for measuring whether broadband deployment to all Americans is proceeding in a reasonable and timely fashion.* FCC, Sixth Broadband Deployment Report, July 20, 2010.

[3] **We mark in boldface items that were specifically responsive to section 2.2 of the RFP**

[4] e.g. "2.5G" or "2.9G" technologies, as they are informally named.

[5] When referring to "Link Technologies" we include the various communications air interface protocols such as CDMA, EVDO RevA, LTE, GSM, EDGE, HSPA+, WiMAX and the like.

will support informal Broadband Map validation efforts. Even if there are temporary shortcomings in performance due to such factors as limited backhaul capacity or high traffic load at the time of measurement, one can infer the maximum practicable throughput based on the installed technology. (Also, a discrepancy between the potential throughput of a Link Technology and its actual performance at a cell site could be a valuable indicator of what may be needed to improve performance in a particular area.)

The second role of logging the best available Link Technology for each service provider at each measurement is as an indicator of things to come. Even today, many 3G technologies may be selectively deployed only to urban and denser residential and higher traffic areas. Because these are the higher-value locations, and because 4G technologies have only begun to be deployed, today's 3G locations are also the most likely locations for initial deployment of 4G services. By **differentiating the collected field data** among the applicable 2G, 3G and 4G services provided by each service provider, there will be a more complete picture of not only the current state of the networks, but also of their likely growth patterns.

PROJECT GOALS

"SNAPSHOT"

The Project's Request for Proposals[6] ("RFP") indicates in its §1.1 Scope the fundamental goal of the Project is, "to provide a real-world snapshot of mobile wireless and potentially fixed wireless broadband data performance and coverage measurements to its portfolio of verification data and sources."

The data collection platform includes augmented GPS logging of time and position of each data point. The output of the test will include various families of tabular files, described further below, representing the key indicators of each carrier and technology monitored.

BROADBAND THROUGHPUT RATES AND SERVICES THAT ARE CONFIGURED

For the fundamental snapshot of mobile wireless broadband performance in Utah, the Project objective is stated in section 2.2 of the RFP as "Wireless Drive Testing."

The data collection will capture typical data throughputs along the drive route. It should be understood that for a given location in a communications network, mobile wireless data transfer is inherently slower than fixed wireless data transfer for a variety of reasons.

[6] International Research Center, LLC *Wireless Verification for the State of Utah RFP*, April 15, 2011

The broadband map is based on "maximum advertised" data rates[7] as required by NTIA BTOP/SBDD definition of broadband ("advertised speeds")[8] During the test, the characteristics of the currently serving cell sites will be collected. Regardless of the actual data transfer speed at the time of data collection, the cell site configuration will identify the maximum practicable throughput available, under perfect conditions. This metric is the most consistent with the maximum advertised speeds. In post processing, a relationship between the maximum and the typical mobile performance can be established for each wireless technology and region (urban/suburban/rural).

DRIVE TEST

The drive test will cover the three road classifications identified in the RFP. A modified Drive Test road inventory provided by Utah AGRC and approved by Isotrope will be employed for the test.

The project team will arrive in Salt Lake City on or about June 29, 2011. The test platform will be installed on June 30. To the extent that Utah representatives can be present, Isotrope will be available on the afternoon of June 30 for staff to observe the installation and setup process for the drive test gear. The test gear will be operational by July 1, at which time (if not sooner) a trial run will be performed and the data will be evaluated. Once the test gear is confirmed as working properly, the drive test will commence.

The initial drive team will consist of David Maxson and Steve Riggs of Isotrope. As time progresses, there may be an occasional substitution of other personnel for either Mr. Maxson or Mr. Riggs, but not both at the same time. Decisions on substitutions, with whom and if/when, will be made ad hoc. Isotrope will make such substitutions without advance approval from IRC, on the condition that either Mr. Maxson or Mr. Riggs is participating in the conduct of the test in person.

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[7] http://utah.gov/broadband/map.html

[8] In contrast, for semiannual FCC reporting, service providers must file form 477, II.a. which says "…entities that are facilities-based providers of broadband connections – which, for purposes of this information collection, are wired "lines" or wireless "channels" that enable the end user to receive information from and/or send information to the internet at information transfer rates exceeding 200 kbps in at least one direction – must complete and file the applicable portions of this form..." This criterion lacks the word "advertised."

Services to Measure

The primary objective of the Project is to conduct a statewide drive test of mobile wireless telecommunications services.

Mobile Services

Mobile broadband services in the following personal wireless service hyperbands will be included in the test. These are the Commercial Mobile Radio Services under Title 47 of the Code of Federal Regulations.

Cellular

The spectrum that the FCC labels as the cellular service band is the original set of frequencies between 824 MHz and 894 MHz that the first two cellular telephone companies in each market were licensed to occupy. This service is articulated in FCC regulations 47 CFR §22.900 *et seq* – ***Cellular Radiotelephone Service***. This service continues to be utilized today. It evolved from its analog start in the 1980's to a full-fledged digital service offering the new generation services as they evolved (the various "2G" and "3G" technologies, for example).

PCS

The FCC service spectrum that was auctioned beginning in 1995 was called Personal Communications Service ("PCS"). This service is codified in 47 CFR 24, ***Personal Communications Services*** and consists of two classes – Narrowband and Broadband. Naturally, it is the Broadband PCS assigned to frequency blocks in the range of 1900 MHz that is of interest to the Project.

Other Mobile Services

Other services that will be used by wireless service providers to deliver mobile broadband connectivity include certain bands listed in 47 CFR 27**,** ***Miscellaneous Wireless Communications Services,*** such as the Advanced Wireless Service ("**AWS**"), Broadband Radio Service ("**BRS**") and the **700 MHz** service.

Table 1 shows in which county each mobile wireless service provider holds a license to provide services. Some additional detail about certain local and regional service providers is incorporated in the table.

	Beaver	Box Elder	Cache	Carbon	Daggett	Davis	Duchesne	Emery	Garfield	Grand	Iron	Juab	Kane	Millard	Morgan	Piute	Rich	Salt Lake	San Juan	Sanpete	Sevier	Summit	Tooele	Uintah	Utah	Wasatch	Washington	Wayne	Weber
ATT GSM UMTS/GPRS • Cell/PCS/AWS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
ATT LTE • 700 MHz		X	X			X									X		X	X				X	X		X	X			X
Sprint PCS CDMA		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
T-Mobile GSM UMTS/GPRS • PCS/AWS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X
Clearwire WiMAX		X	X	X	X	X	X	X		X		X		X	X	X	X	X		X	X	X	X	X	X	X		X	X
Leap CDMA EVDO • PCS		**X**	**X**	x	x	**X**	x	x	r	x	r	x	x	x	x	x	x	**X**	x	x	x	x	**X**	x	**X**	**X**	r	x	**X**
VZW CDMA EVDO • Cell/PCS/AWS	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
VZW LTE •700 MHz	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Manti (Breakaway) CDMA EVDO • PCS	x								x		x	x	x	x		x			x	**X**	x					x	x	x	
Strata Uintah Basin CDMA, 1xRTT • Cell/PCS/AWS				x	x		**X**			x					x							x		**X**		x			
All West Wireless: CDMA 1xRTT • PCS															x							x							
Silverstar PCS (wyoming)					x																								
Chinook (cellular one)					x												x												
Smith Bagley (Cellular One)																			x										
Commnet PCS (roaming provider)	X								X				X															X	
Commnet 700 (roaming Provider)													X						X										
Union PCS			x		x		x			x							x							x					
Union 700 MHz	x				x						x						x										x		

TABLE 1- INVENTORY OF RELEVANT SERVICE PROVIDERS

- Any appearance of the letter "X" or "x" indicates carrier is a holder of one or more FCC licenses in county,
- **Bold Capital X** indicates a comparison was made with the Utah Broadband Map and the carrier shows broadband service in that county
- lower case x indicates FCC licensed in county, but not shown on BB or provider map as native service,
  - black lower case x indicates provider map or BB map shows roaming data,
  - blue lower case x shows no service on provider BB map
- lower case r indicates carrier shows on BB map that it has roaming service in county where is has no license of its own

CARRIERS UNDER TEST

The primary providers of mobile broadband wireless services are the familiar first-tier national carriers who have been providing wireless telephone services to the marketplace: T-Mobile, Sprint, AT&T Mobility, and Verizon Wireless. Second tier national providers Leap Wireless and Clearwire are also included. National provider MetroPCS is licensed in the region, but public information indicates that service to the Utah market has not yet been launched.

Local and regional providers are considered; however Table 1- Inventory of Relevant Service Providers illustrates how several such providers are not active in the state. Two exceptions are noted. According to advertising and to the information accumulated on the Utah BB map, Manti (Breakaway) and Strata (Uintah Basin) are active in a total of three Utah counties. To the extent these providers offer broadband or near-broadband service, they shall be included in the test.

COUNTY MATRIX

The test is conducted statewide, with routes repeatedly crossing county lines. To ensure an efficient testing process that provides comprehensive results for all mobile wireless broadband service providers, the test system must be configured to capture all relevant services in each county. A key method of minimizing technical and operational complexity will be to exploit roaming arrangements among service providers. If a regional or local service provider's network will be accessed under a roaming agreement routinely by a major carrier that lacks native service in a particular county, there will be no need to reconfigure the test gear to access the local or regional provider's service directly. The test system will log roaming activity and identify the network on which the device is roaming.

To facilitate the use of roaming in the test program, project stakeholders have agreed to report to Isotrope how each provider roams in non-native counties, if such information is available from cooperating providers. Isotrope will adjust the providers provisioned in the test system, by county, to accommodate any services that might otherwise be missed with the primary configuration of the test system. The primary configuration is outlined in a section below.

SERVICES UNDER TEST

The voice communications service providers utilize one of two families of technology: GSM or CDMA. These are the names for the second generation ("2G") technologies that form the foundations of their networks. Each technology was expanded upon since their inception in the 1990's.

AT&T and T-Mobile offer service on a GSM platform. GSM was expanded with data services such as the early GPRS, and the more recent EDGE. The third generation technology – HSPA – has been adopted by T-Mobile and AT&T among others. Recently, the HSPA technology has been further expanded in scope, enabling it to earn designation as a 4G technology.

Sprint, Leap and Verizon offer service on the CDMA platform. Basic CDMA technology (under the IS-95 specification, then CDMA2000) has been expanded with data services called 1xRTT, and subsequently EVDO

Technology Category	Data Technology Version	Throughput Rates - Theoretical
GSM	GPRS	Up to 100 kbps forward link, depending on assignment of 1 to 5 time slots and of one of 4 coding schemes dependent on signal reception quality[9]
	EDGE	Up to 300 kbps forward
CDMA 2000	1xRTT	154 kbps packet data with 50-90 kbps average end user
	1xEV-DO Release 0	2.4 Mbps peak, 400-700 kbps average end user rate
	Enhanced EV-DO, Revision A	3.1 MBPS forward (1.8 Mbps reverse)
	Scalable Bandwidth EV-DO	Aggregates up to 15 radio channels for up to 48 Mbps forward (27 Mbps reverse)
UMTS	Release 99	64 kbps circuit/384 kbps packet data – 64-250 kbps average end user
	HSDPA Release 5	1.8 to 14.4 Mbps forward link, scaled by amount of resources assigned to user
	HSUPA Release 6	5.7 Mbps reverse link
	HSPA+ Release 7	28/11 Mbps forward/reverse
	HSPA+ Release 8	42/11
	HSPA+ Release 9 & 10	84-168/23
	HSPA+ Advanced	336/46
LTE		73-150/36-75 Mbps
	LTE Advanced	Up to 1 Gbps/375 Mbps
WIMAX		Up to 63 Mbps in a 10 MHz radio channel, ideal conditions and use of MIMO multi-antenna technology. Double that for 20 MHz channels.

TABLE 2 - LINK TECHNOLOGIES AND THEIR DATA BANDWIDTH CAPABILITIES

The sole operator of mobile WiMAX services[10] in Utah is Clearwire. Deployment in Utah is presently limited to portions of urban areas. Unlike the CDMA and GSM families of services, the Clearwire WiMAX network consists of one link technology that will operate within a single

[9] All current data transmission technologies in this table adjust data rate depending on radio channel bandwidth available and the quality of the link between base station and subscriber. Maximum theoretical throughput is based on maximum assignment of channel bandwidth to the data transfer and on best quality signal conditions.

[10] Mobile WiMAX services are set up on a regional "cellular" model and are designed to reach mobile and nomadic devices.

range of throughput performance. The other services' multi-layered link technologies present a more complex discovery and measurement challenge with the presence of more than one link technology on a service provider's network.

The most recent deployment of link technology in Utah is the fourth generation LTE technology. In June 2011, Verizon Wireless has officially launched LTE data services in limited areas and will expand the coverage of the LTE network in the coming months. We have no reports that any other provider has begun LTE data services in Utah.

Because LTE is an emerging technology, handovers from the Verizon 2G/3G network to LTE may have considerable latency. Because the coverage footprint of the Verizon LTE network is geographically relatively small at this time, the latency of handing up a mobile data call from 2G/3G to LTE may limit the time during which the LTE data rates are measured within the LTE footprint. To minimize the impact of this possible condition, two measurement policies are imposed. First, as with other link technologies, the Main Platform will gather LTE service availability data to the extent practicable even if the current data transfer is occurring on a lower-tier link technology. Second, as the Verizon LTE footprint is relatively small, the test team will anticipate where LTE service is expected to be available and monitor the effects of hand-up-to LTE latency. Upon observation, if it appears that a significant reduction in useful information on LTE service results from hand-up latency issues, the project team will consider minor remedial activities. Such activities might include – if practicable – slowing the vehicle in transition zones, installing a dedicated LTE measurement UE, running the route at transition zones from LTE to 2G/3G coverage to collect data on hand-downs or manually forcing a hand-up to LTE when available. *[Ed. note: It was found during the field configuration of the test platform that the user equipment and test platform did not support handovers between technologies. A field decision was made to measure LTE performance in the Salt Lake City area where it was newly activated. For the remainder of the survey, Verizon CDMA technologies were tested, including occasional sorties through the Salt Lake City area in the conduct of wider area surveying.]*

TEST SYSTEM PRIMARY CONFIGURATION

The primary configuration of the test system will include user equipment ("UE") that is provisioned to operate on the AT&T, T-Mobile, Sprint, Leap, Clearwire and Verizon networks. The UE will be installed in a radio frequency energy transparent radome mounted on the roof of the test vehicle. UE will be positioned to minimize mutual coupling between device antennas. Unnecessary radio emissions of the UE, such as Bluetooth and WiFi, will be disabled.

MAIN PLATFORM

All UE, with the exception of Clearwire UE, will be connected by cables to a ZK-SAM controller and data collection system. This is the "Main Platform." The Main Platform will monitor network status of each Active Network. An Active Network is a mobile wireless network whose services are available in the county that the test vehicle is in and that is configured for measurement by the test system. The primary configuration of the Main Platform will be changed to accommodate regional and local service providers that are identified in Table 1-

Inventory of Relevant Service Providers, as needed. *[Ed. note: due to the success of roaming data collection, Main Platform configuration remained constant throughout the survey.]*

WiMAX Platform

A Clearwire UE will be connected to a computer that will control data collection. This is the "WiMAX Platform."

WiFi Platform

The stakeholders and Isotrope agreed to add a WiFi "wardrive" to the test program. This test will be performed with an external antenna connected to a computer running wardrive data collection software. The software will be configured to log the appearance of WIFi nodes that are configured as access points. The results will include personal, industrial, commercial private and commercial public access points. As the software scrolls through the unlicensed spectrum that includes the 802.11a/b/g/n link technologies, it will repeatedly capture some access points' communications, providing a range of locations where a particular access point is accessible.

Main Platform Data

The following data will be collected for each link technology monitored. Data are collected in various record formats depending on the link technology and the information collected. In general, the data collected on each link technology will include signal characteristics such as signal strength and signal-to-noise-and-interference ratio. The characteristics of the communications link between the base station and the UE are logged, including such attributes as cell ID, carrier ID, the settings of the link technology (from which maximum practicable bandwidth can be inferred). Events such as handovers and connection failures will be logged. In addition to the status information on the communications link, the data throughput test will log data transfer rates at regular intervals, even if a file transfer does not complete. Where applicable, the throughput rates of completed file transfers will be available, although in some instances it will require post-processing of the data to identify start and end times of the file transfers.

Port

Each record or file, as applicable, will be identified with a port number indicating the UE that is connected to the data collection. The Primary Configuration will maintain a consistent use of the same port for the same service provider. When a UE must be changed to one that is subscribed to a difference service provider, a notation of the time and data of the change will be made in the Field Test Log. In addition, many records will contain the unique identifier of the wireless carrier whose network is being accessed by the UE at a given time and whether that connection is native or roaming from the service provider the UE is subscribed to.

Port	Primary Configuration Service Provider
1	AT&T
2	T-Mobile
3	Leap
4	Sprint
5	Verizon

GPS AND TIME

Each record will contain GPS time and GPS coordinates. The GPS receiver is independent of the UE and will provide a master time and position value that will be consistent among the data collected on all five ports. The GPS receiver employs an augmentation protocol that increases the specified accuracy to better than 7.6 m horizontal offset 95% of the time. A wide ranging study found the actual offsets to be typically less than 3 m 95% of the time. Other equipment will also be logging GPS time and coordinates independently, in the event of a primary GPS failure.

Attribute	Note
Date	
Time – Local	
Time – UTC Offset	
Latitude	Blank until first fix is acquired. Updates in every record. Holds last value if fix is lost. (See Fix)
Longitude	Blank until first fix is acquired. Updates in every record. Holds last value if fix is lost. (See Fix)
Fix?	Blank if fix is lost

The following tables provide lists of key attributes that will be collected based on the link technology in use. Different record/field structures are described in separate tables. Data files will be segregated accordingly. All records have a time/location stamp.

CDMA PC

Attribute	Note
Time/Date/GPS Information	
UE Port	
Status	Phone is either Synchronizing, Paging, or Handling Traffic.
Hyperband	Cellular, PCS, AWS…
Frequency Channel #	Based on standard for the applicable hyperband
Receive AGC (also called “RSSI”)	
Transmit Power Adjustment	Indicates how hard UE is working to stay linked to base
Base Station ID	Carrier Assigned Identifier
System ID	Carrier Assigned Identifier
Network ID	Standard Nationwide ID for Carrier
Aggregate Ec/Io of active codes	A signal to interference ratio indicating quality of the radio channel in use
Number of active codes	Number of cell site sectors available and activated for carrying a call

CDMA HANDOFFS HC

Attribute		Note
Time/Date/GPS/Port Information		
Before Handoff	After Handoff	
Phone State		
Hyperband		
Frequency channel		
AGC (“RSSI”)		
Frame Error Rate		
Base ID		
System ID		
Network ID		

GSM PG

Attribute	Note
Time/Date/GPS/ Port Information	
Hyperband	Cellular, PCS…
Frequency Channel #	Based on standard for the applicable hyperband
Base Station ID	
RSSI	28 RSSI sub – accounts for discontinuous mode transmissions
Receive Data Quality	8 point scale corresponds to BER
Transmit Power Adjust	Indicates how hard UE is working to stay linked to base
Timing Advance	Indicates if distance from cell site is significant
Carrier to Interference Ratio	A signal to interference ratio indicating quality of the radio channel in use
Network Code	

GSM NEIGHBORS NG

Attribute	Note
Time/Date/GPS/ Port Information	
Repeats for serving channel and up to 6 neighbors:	Serving channel blank if in UMTS mode
Hyperband	Cellular, PCS…
Frequency Channel #	Based on standard for the applicable hyperband
Base Station ID	
RSSI	28 RSSI sub – accounts for discontinuous mode transmissions

GSM HANDOFF HG

Attribute		Note
Time/Date/GPS/ Port Information		
Before Handoff	After handoff	
Hyperband		Cellular, PCS…
Frequency Channel #		Based on standard for the applicable hyperband
Base Station ID		
RSSI		28 RSSI sub – accounts for discontinuous mode transmissions
Receive Data Quality		8 point scale corresponds to BER
Transmit Power Adjust		Indicates how hard UE is working to stay linked to base
Timing Advance		Indicates if distance from cell site is significant
Carrier to Interference Ratio		A signal to interference ratio indicating quality of the radio channel in use
Network Code		

UMTS PU

Attribute	Note
Time/Date/GPS/ Port Information	
Hyperband	Cellular, PCS…
Device State 19	Idle, Paging, Dedicated…
Frequency Channel # 21	Based on standard for the applicable hyperband
RSSI 24	Carrier RSSI for specific scrambling code
Mobile Network Code 33	
Location Area Code 34	
Cell ID 38	
Number of Inter-frequency Channels Available 41	Communications channels available on other RF channels
Number of Active Channels 45	Up to 6
Number of Intra-frequency Neighbors 46	Neighbors found on same frequency and same communications code
Active Code Ec/Io 49	Signal to interference ratio
Active Code RSCP 50	Received Pilot Signal Code Power
RSSI 51	Received Channel Code Power
Repeat previous four items for up to six Actives	

UMTS HANDOFF HU

Attribute		Note
Time/Date/GPS/Port Information		
Before Handoff	After Handoff	
Device State 19		Idle, Paging, Dedicated…
Hyperband 20		
Frequency channel 21		
RSSI 24		
Mobile Network Code 33		
Location Area Code 34		
Cell ID 38		
Number of Inter-frequency Channels Available 41		Communications channels available on other RF channels
Number of Active Channels 45		Up to 6
Number of Intra-frequency Neighbors 46		Neighbors found on same frequency and same communications code
Active Code Ec/Io 49		Signal to interference ratio
Active Code RSCP 50		Received Pilot Signal Code Power
RSSI 51		Received Channel Code Power
Repeat previous four items for up to six Actives		

EVDO PE

Attribute	Note
Time/Date/GPS/Port Information	
Device State 16	Acquisition, Sync, Idle, Access, Connected
Hyperband 26	
Frequency channel 27	
Serving Pilot SINR 29	Signal to interference and noise ratio of pilot channel
RSSI Antenna 1	
RSSI Antenna 2	
Sector ID	24 LSB of Sector ID
Number of pilots in active set	Up to 6
Number of Pilots in Candidate Set	
Transmit Power Adjustment	Indicates how hard UE is working to stay linked to base
Number of active codes	Number of cell site sectors available and activated for carrying a call

EVDO Handoff HE

Attribute		Note
Time/Date/GPS/Port Information		
Before Handoff	After Handoff	
Device State 16		Acquisition, Sync, Idle, Access, Connected
Hyperband 26		
Frequency channel 27		
Serving Pilot SINR 29		Signal to interference and noise ratio of pilot channel
RSSI Antenna 1		
RSSI Antenna 2		
Sector ID		24 LSB of Sector ID
Number of pilots in active set		Up to 6
Number of Pilots in Candidate Set		
Transmit Power Adjustment		Indicates how hard UE is working to stay linked to base
Number of active codes		Number of cell site sectors available and activated for carrying a call

LTE, LTE Handoff PL, HL

New technology upgrade to test gear. Available attributes are not formally documented yet. Isotrope will identify attributes similar to those in other technologies and generate a set of tables.

Data Testing DTS

Attribute	Note
Time/Date/GPS/ Port Information	
Hyperband	Cellular, PCS…
Band	Indicates the licensed frequency block within the hyper band; e.g Blocks A-F in the PCS hyperband
Base Station ID	
Link Technology	Various flavors of CDMA, GSM, UMTS, LTE protocols from which absolute maximum potential throughput can be inferred
Receive Data Quality	8 point scale corresponds to BER
State of Connection	Connection attempt/established/upload/download/termination
Termination Type	Normal or various types of abnormal
Session ID	In the event there are simultaneous connections being logged, such as uplink and downlink

Transfer ID	Sequential number of file transfer during current session (connection)
Bytes Transferred	Current number of bytes completed in current transfer
Bytes Remaining	Remaining bytes to transfer
Average Throughput	Average file throughput (application layer) since start of current transfer
Current throughput	Throughput over past 5 seconds divided by 5 seconds (updates every 1 second)
GPRS or EDGE mode?	
GPRS/EDGE coding scheme assigned (uplink or downlink as applicable)	Indicates channel coding complexity, based on quality of link to base. Higher link quality, higher complexity, higher throughput rate
GPRS/EDGE timeslots assigned	More time slots are assigned with less traffic contending for the channel
GPRS/EDGE/UMTS/HSPA Radio Link layer throughput	Includes errors and retries – can be used to assess efficiency
EVDO State	Acquisition, sync, idle, access, connected
EVDO Rev 0 (only) Forward Good/Bad Data served	Master counter of all Rev 0 forward data served since start of test run – two figures: good & bad. Must run calculations to obtain short and long term averages. Updates ~ once a second.
EVDO Rel. A (only) Reverse Physical Throughput	NEED INFO63
EVDO Forward Current Throughput	NEED INFO64
EVDO Data Rate – Forward or Reverse as applicable	Indicates data rate granted to the connection based on channel coding complexity, based on quality of link to base. Higher link quality, higher complexity, higher throughput rate assigned
EVDO RLP (Radio Link Layer) 67-68Current throughput,	(fwd and rev as applicable)
EVDO RLP Total bytes in measurement session	Fwd and Rev as applicable
EVDO RLP throughput interval	
UMTS Spreading Factor	
Number of HSDPA Codes assigned	Provides information on the resources assigned to the UE based on channel quality and/or traffic loading
HSDPA MAC layer throughput	One second – Bytes/sec, only for blocks with good CRC
HSDPA MAC layer throughput	5 sec interval averages (Field 39 interval)

Attribute	Note
Time/Date/GPS/ Port Information	
Hyperband	Cellular, PCS…
Band	Indicates the licensed frequency block within the hyper band; e.g Blocks A-F in the PCS hyperband
Base Station ID	
Link Technology	Various flavors of CDMA, GSM, UMTS, LTE protocols from which absolute maximum potential throughput can be inferred
Link Session ID	Combines Phone ID with Unit ID for unique ID
Total Link Bring-up Time	Total time to "dial in" and establish data connection. Blank until established.
Data Link State	Normal or various types of abnormal attempts/established/terminations
Dial-up time	One part of Total Bring-up Time
Link-connect time	Another part of Total Bring-up Time

WiMAX and WiFi Platforms

WiMAX

The WiMAX link technology employed by Clearwire will be monitored and logged with a dedicated test platform. Information will be limited to data rates, location, time. Because the Clearwire network is monolithic (no layering of various link technologies) the configuration of each cell site will be the same. The external variables affecting signal quality due to mobile UE speed, distance from cell site, and interference, plus any effects of traffic loading, will be the only variables in the WiMAX test.

WiFi

Conventional “wardriving” tools will be employed to capture available WiFi access points.

Attribute	Note
Time/Date/GPS	
Hyperband	2.4 and 5 GHz
RF Channel	
SSID	User-assigned name for the access point
Hardware Manufacturer	Software cross-indexes hard coded MAC address to a registered manufacturer. High probability of correct identification. This information may help distinguish between consumer-installed access points and commercial ones.
Link Technology	802.11 a, b, g or n
Authentication and Encryption Type	
Configured Maximum Data Transfer Rate	Access point instructs UE as to the data transfer rate setting of the link technology, when variable
Signal strength	

Test Apparatus

Specially selected and equipped wireless devices are plugged into a controller’s USB data ports. The computer is programmed to initiate and supervise the measurement cycles and simultaneously capture the data from multiple wireless devices.

The wireless devices will be mounted in a weather tight radome mounted on the roof of the test vehicle. They will be remotely powered and controlled via USB cable connection to the interior of the vehicle, where the controller will be installed. The controller has a real time display of system and device activity.

The controller has alarm functions. The test team will configure alarms to help identify faults in the measurement process, such as alarms that indicate when a device is no longer communicating with the controller (due to loss of power or firmware freeze-up) or when a device has lost contact with its network.

The test team will be cognizant of the potential for unwanted radio frequency emissions to disturb or interfere with the data collection process. Other emitters in or near the radio spectra under test will be kept away from the devices under test.

The test team will inspect and monitor operations for continuing performance, and for possible effects of thermal, humidity and mechanical stress. The UE will be mounted within the radome in a manner that maximizes the spacing between devices, thereby minimizing mutual coupling of the emissions of their antennas.

TABLE 3 – ZK CELLTEST - BENCHMARKING SYSTEM

ZK-Cell test ZK-SAMp Drive Test Platform including:	
ZK-SAMp System Access Monitor with 5 ports	ZK-SAMp-A Device Air interface- CDMA/1xRTT/EvDO-0/EvDO-A
ZK-SAMp-H Device Air interface- GSM/GPRS/EDGE/UMTS/HSPA	ZK-SAMp-L Device Air Interface- LTE

TEST PROGRAM EXECUTION

REALISTIC INTERPRETATION OF COLLECTED DATA

As a mobile test, the project will be able to gather substantial information about numerous services over a significantly broad geographic area. One consequence of mobile testing is that the nature of mobile communications – relying on low gain UE antennas that are in constant motion – militates against ideal communications performance. Fixed communications links will consistently have higher data throughputs than a mobile link on the same network. For example, Figure 1 shows the range of performance of several wireless devices in mobile and fixed operation. The data collection protocol includes the collection of link technology capability from which the advertiseable or absolute maximum throughput rates can be inferred.

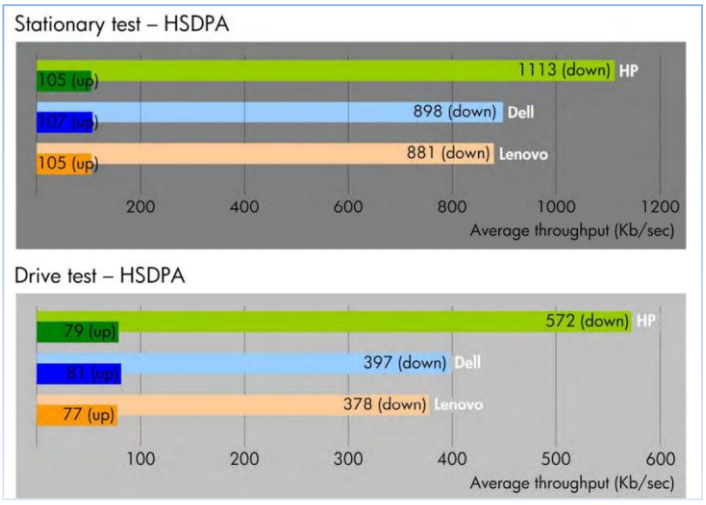

FIGURE 1- COMPARISON OF STATIONARY AND DRIVE TESTS OF THREE LAPTOP MOBILE WIRELESS DATA MODULES [SOURCE: METRICO WIRELESS, INC & HP]

FIGURE 2 - CARTOP CARRIER SIMILAR TO THAT WHICH WILL BE USED AS A RADOME FOR DRIVE TESTING

FILE TRANSFER TESTING

Wireless data speeds span several orders of magnitude. While 2G technologies tend to run under the 768 kbps downlink speed that is defined as broadband, and 3G technologies have been delivering speeds in the vicinity of 768 kbps, perhaps up to 2 Mbps, in practical usage, the 4G technologies (LTE and HSPA+) are now being provisioned to deliver rates about 10 times faster, up to a practical rate near 20 Mbps. Isotrope obtained 15 mbps downlink and 5 mbps uplink speed on the just-launched Verizon LTE network in Salt Lake City in early June.

Considering that the test platform will collect real-time throughput data at 5 second intervals, whether or not the entire file has transferred, it is reasonable to select a file size that may be larger than the slow data services can readily deliver. A slow data rate of 100 to 500 kbps will be identified as readily with a large file as a small one. In contrast, because the objective of the test is to characterize broadband performance as the technology can deliver today, it would be advisable to use a file size that is not insignificant to the faster 3G and 4G services, such that several data points at 5 second intervals could be taken during one file transfer event.

Assuming a three-decade range of 20 Mbps, 2 Mbps and 0.2 Mbps (200 kbps), and a 6 second transfer at the highest speed, a file with 6*20/8 = 15 megabytes (MB) would be necessary. At 2 Mbps, this same file would require 1 minute to transfer. At 0.2 Mbps, it would be 10 minutes.

Using the ratio of 200 kbps uplink to 768 kbps downlink, uplink speeds are nominally ¼ of the downlink speed. ¼ of the 15 MB downlink file size would be approximately 4 MB for an uplink file.

Isotrope will employ a 15 MB data file for downlink testing and a 4 MB file for uplink testing. If initial testing in Salt Lake City, where there are 4G services available, indicates a lesser file size will work well, or that a larger file size is necessary, Isotrope will consider the benefits of changing the file size for the remainder of the test, and inform the client of any such recommendation. *[Ed. note: Final uplink and downlink file sizes for each technology platform were selected in the field and are reported in the <Look-Up Tables.xslx> file in the Test Packet Size tab.]*

Mobile Services Data Collection

Collected data will be backed up off-vehicle at least daily to ensure data are protected from accidental loss in the field and data collection is running smoothly. The initial drive testing will be performed in the Salt Lake area in the event it becomes necessary to address technical issues that crop up early in the testing program.

Isotrope will consolidate the data and on a daily basis review them for completeness and consistency. As data becomes ready, draft copies will be posted for client review. Post processing will consist of viewing relevant data for consistency and consolidating data to files and file groupings that are easiest for the client to ingest. The file groupings will be separated by service provider. Subgroupings of files will include each of the file types described in the tables above. The above tables list key attributes that will be collected, but do not represent the final record and field structures. Final structure will be developed and documented. *[Ed. note: file structures are presented in <Isotrope File Structure 20110802.xslx> and various cross reference lists are contained in <Look-Up Table.xslx>.]*

The test team will not perform any statistical analysis or derivative GIS layer development, other than separating desired data sets into their own GIS layer files as agreed upon.

Project Timeline

The map of roads to be tested is in final revision, pending agreement of the vendors and client. The expected duration of five weeks from start of data collection is reaffirmed by the initial drive routing prepared by Isotrope. There will be a deadhead ratio that is about one mile for every two miles of required data collection, resulting in approximately 9000 miles of test route.

At the initiation of testing, Isotrope will share its itinerary with the client. During the performance of the testing, Isotrope will provide updates no less frequently than once a week on its progress on the drive route.

Isotrope arrives in state on June 29, 2011 and commences work immediately.

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